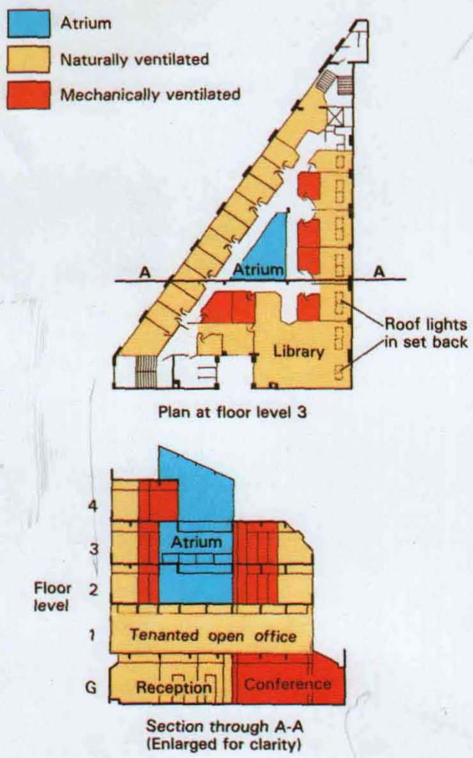
December 1989

BEST PRACTICE PROGRAMME

Good Practice Case Study 1

ENERGY EFFICIENCY IN OFFICES

Low cost major refurbishment
Policy Studies Institute
100 Park Village East, London NW1



Plan at floor level 3

Section through A-A
(Enlarged for clarity)

- New atrium avoids the need for air-conditioning.
- New, smaller double-glazed windows improve thermal performance.
- Good daylight gives low lighting costs.
- Air quality sensors regulate fresh air intake.
- Solar energy collection from atrium exhaust air.

The Project

The Policy Studies Institute (PSI) is an independent policy research organisation concerned with economic and social studies and the workings of political institutions. Their research work benefits from a cellular office environment, with extensive support facilities including a conference suite which is regularly rented-out.

A 5-storey office building in poor condition, was purchased for low-cost conversion into the necessary office accommodation, with library, conference, meeting rooms and kitchen. The building (originally a 1920's factory) has an unusual triangular floor plan.

PSI and their landlords — the Joseph Rowntree Memorial Trust — wanted the project to be as energy efficient as a limited budget would allow. The major design problem was to reconcile the large number of cellular offices needed with the windowless space in the centre of the building, whilst avoiding expensive air conditioning.

The Result

A small atrium was pierced through the top three floors to give a focus to the scheme, bring light and air to the centre of the building, expand the perimeter for cellular offices, avoid the need for air-conditioning, and collect solar heat.

The design solution allowed many of the rooms to be naturally-ventilated, with mechanical ventilation to the atrium and surrounding offices only, and to conference and meeting rooms on the ground floor. Most of the windows were replaced or upgraded with double-glazed units. Roof insulation was improved, but retrofit wall insulation was not economic. The boilers were overhauled.

The resulting building enjoys a moderate energy use of 193 kWh/m^2 of heated floor area, with particularly low electrical and lighting costs. Heating energy use predominates (85% of energy consumption and 55% of energy cost): it could have been significantly lower had the old boilers been replaced with modern high-efficiency equipment.

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Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

CI/Sfb 1976 32 R3 W8 Y7

Heating System

The two existing cast-iron sectional boilers were overhauled and converted to gas firing with new high/low burners. Although this gave capital cost savings, to have installed new, smaller high-efficiency gas boilers at the time of refurbishment might well have reduced the current level of gas consumption by some 30%, saving perhaps £1500 per year and recovering the additional cost within 3 to 5 years. The boilers supply a constant-temperature low pressure hot water circuit to the ventilation plants and a separate variable-temperature "compensated" circuit (via a 3-way mixing valve) to new radiators around the perimeter of the building.

Heating Controls

A single controller in the boiler room provides a 7-day time programme for the ventilation plants, plus optimum start, stop and external temperature-linked compensation for the perimeter heating. Radiators also have thermostatic valves to permit individual room temperature control and to take advantage of solar and internal heat gains.

Domestic Hot Water

In most offices, the demand for hot tap water is small and the use of a central boiler supply is often uneconomic. In the refurbishment, the hot water supply was therefore disconnected from the boilers and local electric water heaters were installed instead: there are four small undersink units (with local on/off switches) and three larger units (with time switch controls) which serve the toilets and the main kitchen.

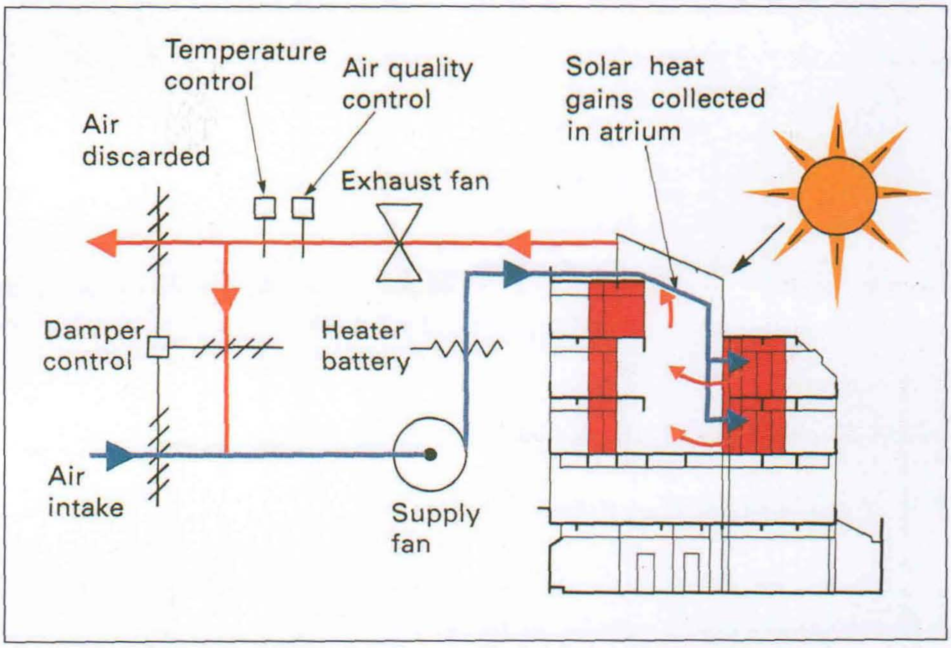
The main kitchen water heater has proved undersized for washing-up after large events: a higher capacity or a local gas-fired unit might have been more suitable.

Mechanical Ventilation Systems

Rooms without external perimeter windows are heated and mechanically ventilated by five separate systems which provide ventilation, warm air heating and "free" cooling to the following zones:

1 Large conference room.
2 Small conference/dining room.
3 Administration and meeting rooms.
4 The Atrium and adjacent offices on the second and third floors.
5 Top floor offices adjoining the atrium.

PSI would have preferred the conference and meeting rooms to have been air-conditioned had this been affordable.



Ventilation Controls

All five ventilation systems run to the same time programme as the perimeter heating (but without the optimum start preheat period). They can also be operated independently under hand control from their individual control panels. Independent control of each plant — with simple local timed over-rides, could have reduced their energy use still further.

The supply-air temperature from each system is controlled from the exhaust air temperature using an electronic two-stage proportional controller acting on 3-way heater battery valves and fresh/recirculation air dampers. As the leaving air temperature rises, the 3-way valves close: when these are fully shut the dampers then open from their minimum fresh air settings to recirculate less return air and to introduce more cool outside air.

Air Quality Control

At times of low occupancy, mechanical ventilation systems can waste heat by bringing-in too much outside air. Varying fresh air needs at PSI are accommodated by using Staefa air-quality sensors in the exhaust air ducts to alter the minimum proportion of outside air admitted.

Solar Air Preheating

By using the atrium as the return air path from the internal offices to the ventilation plant, solar heat gains into the atrium can either be recovered (with consequent savings in heating energy), or discarded (helping to reduce peak temperatures). This gives a simple "active" solar air pre-heating system, and also saves the cost of the return air ductwork which would otherwise have been required.

Lighting

Lighting is largely fluorescent, using locally-switched twin-tube recessed fittings with low-brightness louvres. At 600 lux (300-500 might have been more appropriate as desk lights are also provided), the illuminance levels are fairly high, as is the installed office lighting load of 20-25 W/m^2. Owing to good daylight, local switching, management policy of energy awareness, electric lighting is used sparingly and running costs are low.

The ground floor conference area has little natural light, and uses relatively inefficient tungsten-halogen fittings. But here again, hours of use are restricted by good management.

Building Team

Architects: Jestico + Whiles,
London NW1
Main Contractor: CP Roberts Ltd
Mechanical Services Design & Installation:
Thermal Transfer Northern Ltd, Glossop.

Building Details

Built in the 1920s, extended 1958, altered and refurbished 1984-85.

Refurbishment cost	£290/m² gross (1985)
Floors: ground +4	Small basement
Gross floor area	2460 m² 26500 ft²
Treated floor area	2380 m² 25650 ft²
Nett lettable floor area	1560 m² 16800 ft²
(incl first floor sub-let 415 m² 4475 ft² nett)	
Typical number of occupants	80
Typical hours of use:	9-5 weekdays.

Fabric	U-value (W/m²K)
Solid walls (original)	1.2
New double glazing (clear glass + reduced area)	3.3
Roof insulation upgraded	0.6

Heating

2 × 322 kW refurbished cast-iron gas boilers
Optimum start/stop and compensation
Perimeter radiators with thermostatic valves
Warm air heating to atrium and internal rooms
Solar air heating via atrium

Hot Water

Local electric storage water heaters
4 × 7 litre open outlet under sink
3 × 70 litre cistern-fed with time switch

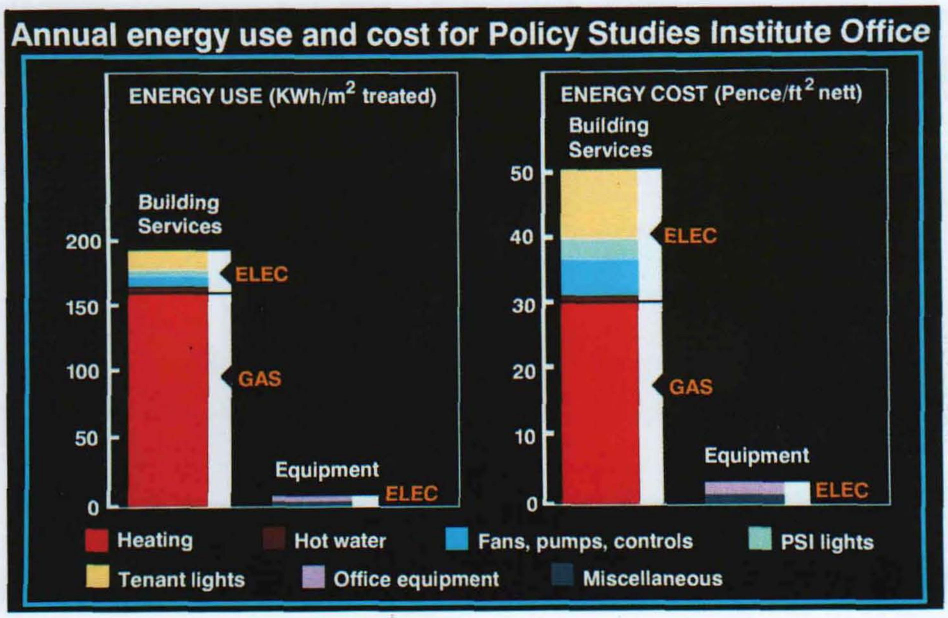
Ventilation

Perimeter offices naturally ventilated.
Internal offices, conference and kitchens mechanically-ventilated by 5 independent warm air plants with fresh air intake controlled from exhaust air temperature and air quality level.

Lighting

Good daylight to cellular offices and atrium.
Local light switching for each room.

Typically 600 lux	22W/m²
First floor 500 lux	15W/m²



The diagram above gives a detailed breakdown of energy use and cost.

From June 1987 to May 1988 390,000kWh of gas and 69,000 kWh of electricity were consumed: 164 and 29 kWh/m² of treated area respectively. This is an energy performance significantly better than the CIBSE Energy Code Part 4's 'good category' for a building of this type. Although the gas energy usage is by far the larger, the 1987/88 bills for gas and electricity were similar at £4930 and £4030: 29 and 24 pence ft² nett respectively.

Heating **164 kWh/m²**

Energy use is higher than in most of the modern buildings featured in these case studies, but is reasonable, particularly in view of the retention of the original boilers and the low internal heat gains from lights and equipment. With new high-efficiency gas boilers, heating fuel consumption could well have been 120 kWh/m² or less.

Hot Water **2 kWh/m²**

Energy use is very low, resulting from the point-of-use electric heaters (some of which were off at the time of the survey) and the fairly low intensity of building use.

Fans, Pumps and Controls **8 kWh/m²**

Energy consumption by pumps and controls is average. Fan energy (6 kWh/m²) is modest as only part of the building is mechanically-ventilated but it could have been further reduced by programming individual plants.

Lighting **16 kWh/m²**

Lighting energy use is very good (at about half the typical level in case study offices): further savings could have been made by improving the efficiency of the fittings in the offices and the conference suite and possibly by lowering the design illuminance levels in PSI's offices.

About two-thirds of this energy consumption takes place on the tenanted first floor (27% of total nett area). Although the lighting here is more efficient, higher occupancy, smaller windows and deep plan require most lights to be left on all day.

In PSI's own accommodation, the daylight is better, the occupancy less intense and energy consciousness high. In the predominantly single-cell offices people can also switch their lights off more freely without fear of inconveniencing others.

Office Equipment **2 kWh/m²**

Office equipment often uses less energy than people expect, and PSI is no exception. Estimated energy use is approximately equally split between photocopiers, personal computers (1 per 3 persons), and other equipment.

Miscellaneous **1.5 kWh/m²**

Lift use is modest (0.3 kWh/m²) as there is relatively little inter-floor traffic and the first floor tenants use it for heavy goods only. Catering use is also small and largely for refrigeration, serving and hot drinks. Meals for conference lettings are usually brought-in by outside caterers.

POLICY STUDIES INSTITUTE

User Reactions

The project has generally met PSI's refurbishment brief at relatively low capital and running costs, and PSI is pleased with the result.

Most occupants prefer the outer perimeter offices (with radiators, individual thermostat controls, external views and openable windows) to the atrium offices which have less light and privacy, internal views, and centrally-controlled warm air heating. The internal offices are therefore now largely used for service functions and for occasional visitors. PSI have been able to accommodate this change, but other organisations might have found it more problematic.

In summer the conference suite gets rather warm, and this is exacerbated by the radiation from the tungsten-halogen lighting. PSI have considered adding cooling to the conference room ventilation system, but as at the outset the price was too high.

General Appraisal

The new atrium was the key to meeting PSI's brief, and it is difficult to see how their needs for small cellular offices could have been met in a deeper space. This demonstrates how the imaginative manipulation of the form and fabric of a building can significantly reduce servicing requirements, capital and energy costs, while enhancing the environment and utility of a space.

Heat losses were reduced by insulating those building elements — particularly windows and roof — which needed upgrading in any event. External wall insulation would only have been cost-effective had re-cladding been necessary, while internal insulation would also have increased the likelihood of over-heating in summer, and reduced internal floor area.

The heating and ventilation systems fall somewhat short of the cost-effective optimum because additional funds were not available at the time to replace the boilers and to provide individual time programme controls for each of the five ventilation plants (saving both heat and fan power). If the budget had permitted new boilers, the heating energy consumption could well have been comparable with many new buildings.

The peak summer temperatures in the conference suite have been disappointing. Without resorting to air-conditioning, potential remedies could include:

- using more efficient light sources with a lower heat output, and extracting the heat excess directly from the space.
- omitting the suspended ceiling to allow the thermal capacity of the floor slab above to reduce temperature swings.
- programming the ventilation system to run overnight when necessary to remove any excess heat and pre-cool the structure overnight using cooler outside air.

The new electric hot water system has been economical, particularly compared with the existing boiler plant, which would have been very inefficient in summer.

While *electricity use* is low for a modern office, its cost still approaches that of the heating.

The installed *lighting* power is average: but lighting costs are modest owing to limited hours of use resulting from good daylight, cellular offices with local switches, fairly low density of occupation, and energy-conscious management. Lighting energy use could have been lower still if more efficient fittings had been used (especially with lower illuminances in the daylit offices) and if the first floor had been able to benefit from the atrium.

For the occupancy, usage and management of the building, the conventional light switches by the door of each office have proved quite an effective means of control: at the low measured energy consumption levels automatic electronic controls would have been unlikely to be cost-effective.

Main Conclusions

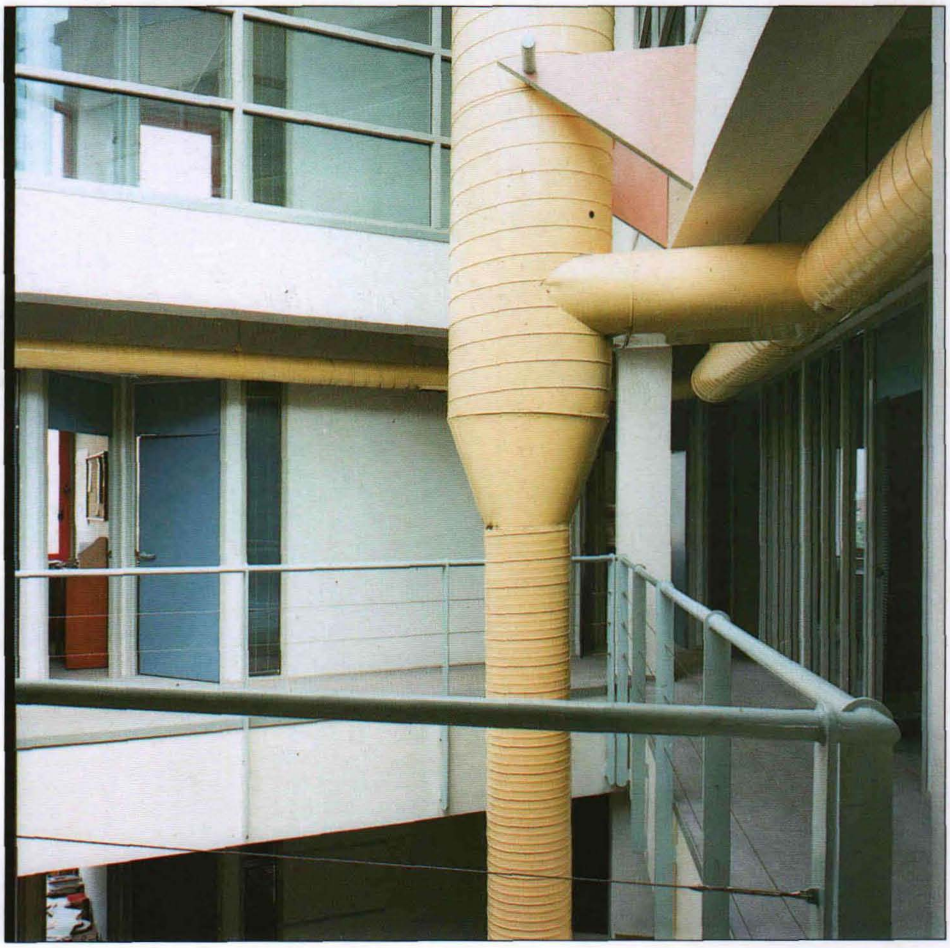
The cellular space requirements and the intermittent occupancy pattern of a research institute has allowed a "domestic" approach to office design to be an energy-efficient one. However, it must be admitted that the density and intensity of use is lower than in many commercial offices.

Modest running costs have been achieved at a relatively low capital cost through a range of architectural, building services, and management measures, matching the building to the needs of its occupants. New boiler plant and additional ventilation system controls would also have been cost-effective but would have stretched the limited capital budget.

Short Notes on the Measurement of Floor Area

Gross	Total building area measured inside external walls.
Nett	Gross area less common areas and ancillary spaces. Agent's lettable floor area.
Treated	Gross area less plant rooms and other areas (eg stores), not directly heated.

PRECISE DEFINITIONS ARE AVAILABLE ON REQUEST



All case study analysis in this series are based on an apportionment of at least one year's measured fuel consumption and cost. Further breakdown into sub-headings is by a combination of sub-meter readings, on-site measurements, and professional judgement. The technique of apportionment is the same for each Case Study and all quoted building areas have been re-measured for the project.

This study has been carried out by the Davis Langdon & Everest Consultancy Group and William Bordass Associates. The cooperation of the owners, designers, managers and the occupants of the case study building is gratefully acknowledged.

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